Full translation of JP 60-68A

SPECIFICATION

1. THE TITEL OF THE INVENTION

A composite system of a fuel cell

2. WHAT IS CLAIMED IS

(1) A composite system of a fuel cell comprising;

a pair of metal tanks individually storing a metal hydride having different hydrogen equilibrium dissociation pressures,

hydrogen transfer valves connecting said pair of metal tanks to each other,

heat exchangers provided on said each metal tank,

a heat exchange provided on a fuel cell,

a second heat exchanger provided on one of said two metal tanks storing a metal hydride having a low hydrogen equilibrium dissociation pressures,

a heat medium passage provided between said second heat exchanger and said heat exchanger provided on the fuel cell

wherein a heat is exchanged in said metal tanks via said heat exchangers provided on said metal tanks.

(2) A composite system of a fuel cell according to claim 1, comprising:

a plurality of said pair of the metal tanks,

the heat exchangers provided on each metal tanks,

wherein a heat is exchanged between the heat exchanger provided on the fuel cell and a second heat exchanger provided on one of a plurality of metal tanks storing a metal hydride having a low hydrogen equilibrium dissociation pressures, and an air conditioning is continuously performed in each metal tank via the heat exchanger provided on each metal tank.

3. DETAIL DESCRITION OF THE INVENTION

Industrial Applicability

The present invention relates to a composite system for performing a power generation of a fuel cell, an air heating and air cooling, and a hot water supply by combining a fuel cell and a metal hydrides.

Prior Art

Generally, it is well known that metals (mainly alloys) occlude hydrogen to produce a metal hydride. In this case, more hydrogen is occluded to a gross unit of metal so as to be reversibly discharged from the metal under the temperate that hydrogen can be used.

A process of discharging hydrogen from the metal hydride is called an endothermic reaction. On the contrary, a process of occluding hydrogen to the metal hydride is called an exothermic reaction.

Specifically, the following equation is known.

Heat is discharged (an endothermic reaction)

$$[MH] + Q \rightleftarrows [M] + 1/2H_2 \uparrow$$

Heat is generated (an exothermic reaction)

Herein, M is defined as a metal, MH is defined as a metal hydride, and Q is defined as a quantity of heat generation.

The above process of the endothermic reaction can be applied to an air cooling, while the above process of the exothermic reaction can be applied to an air heating and a hot water supply.

An air conditioner is disclosed as an apparatus. In the apparatus, a heat discharged from the metal hydride as well as a solar heat is utilized as a heat source. Thus a compressor is not utilized in the apparatus so that a great noise is not

generated. (For example, Japanese unexamined Patent Publication S51-22151 and Japanese unexamined Patent Publication S51-832942)

On the other hand, with regard to a fuel cell apparatus for performing a power generation, a large quantity of heat is discharged from the fuel cell in addition to gaining an electric power. Accordingly, unlike other power generators, the fuel cell apparatus has the following advantage. The heat quantity can be utilized effectively so that approximately 80 % of a high total heat efficiency can be expected.

In accordance with the above advantage, it has been desired to provide a system having a few mobile parts capable of performing a high efficient power generation as well as capable of efficiently utilizing a heat in which a great noise is not generated and a harmful gas is not emitted.

In order to realize the above mentioned requirement, the present invention has been made to obtain a composite system for a power generation of a fuel cell as well as an air heating and cooling by combining a fuel cell and two kinds of metal hydrides having different hydrogen equilibrium dissociation pressure. In the composite system, total heat efficiency can be improved by using the fuel cell while an air heating and cooling as well as a hot water supply can be performed during a course of a power generation.

SUMARAY OF THE INVENTION

A composite system of a fuel cell for a power generation as well as an air cooling and heating comprising of a pair of metal tanks individually storing a metal hydride having different hydrogen equilibrium dissociation pressures, a heat exchanger provided on the metal tanks, wherein a heat is exchanged between a metal hydride having a low hydrogen equilibrium dissociation pressures and a fuel cell, and wherein an air heating and cooling caused by the metal hydride, a hot water supply by heating water, and a power generation of the fuel cell is performed.

The EMBODIMENT OF THE PRESENT INVENTION

Fig.1 indicates a heating and cooling cycle of a metal hydride. In accordance with a characteristics of two kinds of metal hydrides (MH1 and MH2) having different hydrogen equilibrium dissociation pressure and the same temperature, the cycle is performed in the following manners. Herein, MH1 is defined as the metal hydrides having a low dissociation pressure, while MH2 is defined as the metal hydrides having a high dissociation pressure.

Firstly, MH1 (Point A) is heated. Thus the dissociation pressure of MH1 is increased so as to be higher than occlusion pressure (Point C) of MH2. (ΔP = Point B - F) Consequently, hydrogen is transferred from MH1 to MH2 due to ΔP so that hydrogen is occluded to MH2 at point C. In this time (Point C), an exothermic phenomenon occurs.

Next, when MH1 and MH2 are cooled, the pressure of both MH1 and MH2 are decreased. Sequentially, as shown in Fig.1, MH1 reaches Point A, while MH2 reaches Point D, respectively. At this time, the pressure of MH2 becomes higher than that of MH1 so that hydrogen is transferred from MH2 to MH1. Specifically, hydrogen is discharged from MH2 at Point D so that MH2 is cooled due to an endothermic action.

Herein, Point A is 50°C and approximately 2.5 atm, Point B is 180°C and approximately 70 atm, Point F is 130°C and approximately 30 atm, Point C is 50°C and approximately 25 atm, and Point D is 5°C and approximately 4 atm, respectively.

Heat efficiency can be improved by heating the metal hydride and by repeating a cooling cycle.

Fig.2 and Fig.3 indicate a power generation of a fuel cell as well as a system of air heating and cooling caused by metal a hydride based on a principal shown in Fig.1.

As shown in Fig.2, a metal tank 4 and a metal tank 10 are connected with each other via valves 11 and 12. Herein, the metal tank 4 includes a heat exchanger 3 connected with a pipeline 5 via a heat exchanger 1 for an air heating and cooling as well as a valve 2. Similarly, the metal tank 10 includes

a heat exchanger 9 connected with a pipeline 8 via a heat exchanger 6 for an air heating and cooling as well as a valve 7. A certain amount of metal hydride 13 (MH3) is put in the metal tank 4, while a certain amount of metal hydride 14 (MH4) is put in the metal tank 10. Furthermore, the metal container 10 also includes a heat exchanger 18 connected therewith via a heat exchanger 16 and a valve 17. Herein, the heat exchanger 16 heats and cools a fuel cell 15. Additionally, solvent for exchanging heat is transferred by means of a pump to circulate solvent so that heat can be smoothly transferred.

As shown in Fig.3, a pipeline 19 for inducing water is divided into two directions. In the one direction, water runs from the metal tank 4 (including a heat exchanger 3 therein) to a pipeline 24 of hot water via a valve 2 so that hot water runs out from the pipeline 24. Meanwhile, in the other direction, water runs from the metal tank 10 (including a heat exchanger 9 therein) to the pipeline 24 of hot water via valves 20, 21, and pipelines of water 22, 23 so that hot water runs out from the pipeline 24. A certain amount of a metal hydride 13 is put in a metal tank 4, while a certain amount of a metal hydride 14 is put in a metal tank 10. The metal tank 4 and the metal tank 10 are connected with each other via valves 11 and 12 for transferring hydrogen. Furthermore the metal tank 10 also includes a heat exchanger 18 connected therewith via the heat exchanger 18 and the valve 7. Herein, the heat exchanger 16 heats and cools the fuel cell 15. Additionally, a heat medium is removed from the fuel cell 15 to the metal tank 10 and vice versa by means of a pump to circulate solvent so that a heat can be smoothly transferred.

As a principle of operating each system, explanations will be made with regard to a power generation of the fuel cell and a function of an air heating and cooling caused by a metal hydride in Fig.2.

When the fuel cell is heated for generating a power in the temperature of 150 to 200 °C to produce an electric power, an efficiency of a power generation is decreased due to a

resistance polarization. In this time, a heat is generated in accordance with a loss of the above power generation. This heat is removed via the heat exchangers 16 and 18 by utilizing a heat quantity generated from the fuel cell so as to heat the metal hydride 14 having a low equilibrium dissociation pressure. Thus hydrogen is discharged from the metal hydride 14 via a valve 11 for occluding hydrogen to the metal hydride 13 having a high equilibrium dissociation pressure. In this time, heat of hydrogen occlusion (amount of heat generation) of the metal hydride MH2 is utilized for heating.

Next, when the valve 17 is closed to suspend transferring a heat from the fuel cell or when power generation of the fuel cell is stopped to decrease a temperature of MH1, hydrogen is transferred from MH2 to MH1 via the valve 12 due to a hydrogen equilibrium pressure difference between MH2 and MH1.

When hydrogen is discharged from a metallic hydride MH_2, the metallic hydride MH_2 is cooled. This is because this kind of reaction is one type of endothermic reaction to deprive ambient temperature. Cooling can be performed by using the metallic hydride MH_2 as a cooling source via heat exchangers 3 and 1. In the meantime, since hydrogen is occluded in the metallic hydride MH_1, a heat is generated in a metallic hydride MH_1. This heat quantity can be also utilized as heating by transmitting the heat via heat exchangers 9 and 6.

An air cooling and heating can be performed due to a reaction of the metallic hydride for the cases that the power generation is started in the fuel cell and that the fuel cell is stopped.

Furthermore, as mentioned above, the heat is generated in the metallic hydride MH_1 when hydrogen is occluded in the metallic hydride MH_1. This heat can be also utilized to increase temperature of the fuel cell so that the fuel cell can be started again at the time when the fuel cell is stopped.

According to Fig.1, it could be proved that when the hydrogen removes from the point C of the metallic hydride MH_2 to the point E of the metallic hydride MH_1, the temperate of

fuel cell could be increased from 50°C to approximately 120°C. Accordingly, this principle makes it possible for the temperature of the fuel cell to increase from 80-100°C to 150-180°C. This is effective actuation to increase the temperature of the fuel cell.

Furthermore, heat quantity discharged from the fuel cell can be directly utilized for an air heating and cooling as well as a hot water supply. What is more, heat quantity discharged from the fuel cell can also be stored in the metal hydride as a heat source in the long-term.

Next, the explanation will be made with regard to a power generation of the fuel cell and a function of supplying a hot water caused by a metal hydride in Fig.3.

As described above, when the fuel cell 15 is heated for generating a power in the temperature of 150 to 200 °C, a large quantity of heat is discharged from the fuel cell 15. The metal hydride MH1 is heated by the above large quantity of heat via the heat exchangers 9 and 16. Thus hydrogen is discharged from the metal hydride MH1 and is transferred to the metal tank 13 via the valve 11. In this time, hydrogen discharged from the metal hydride MH1 is occluded to the metal hydride MH2. Heat quantity generated by the occlusion is transferred to water medium via the heat exchanger 3. Thus the water medium is heated so as to be hot water. The hot water is utilized for a supply.

Next, when the valve 17 is closed to suspend removing a heat from the fuel cell or when power generation of the fuel cell is stopped to decrease a temperature of MH1, hydrogen is removed from MH2 to MH1 via the valve 12 due to a hydrogen equilibrium pressure difference between MH2 and MH1.

In this time, since hydrogen is occluded to the metal hydride MH1, heat is generated. A temperate of the heat medium is increased by the heat via the heat exchanger 9 so as to be supplied as a hot water. Herein, the water medium runs from the pipeline 19 of supplying water to the pipeline 22 via the valve 22.

In Fig.2 and Fig.3, the metal hydride MH1 and MH2 are

coupled each other through the hydrogen transfer valves 11 and 12.

In Fig.2 and Fig.3, the metal hydride MH1 is put in the metal tank 14, while the metal hydride MH2 is put in the metal tank 13. The metal tanks 13 and 14 are coupled each other through the hydrogen transfer valves 11 and 12. Specifically, the metal hydride MH1 and MH2 are provided as a pair of the metal hydrides.

For example, supposing that more than two pairs of the metal hydrides MH1 and MH2 are provided, a heat discharged from the fuel cell can be alternately supplied to the metal hydride MH1 of each pair. Thus an air heating and cooling or a hot water supply can be consciously performed. Additionally, an electric force can be continuously generated from the fuel cell.

Next, the embodiment of the present invention will be now described more correctly.

The fuel cell of the present invention is operated under the condition that solvent of oxide phosphorus is used as the electrode, air is used as oxidant, and hydrogen gas is used as fuel. The output of the fuel cell is 20 KW (100V × 200A).

Supposing that efficiency of power generation of the fuel cell is 40 %, total heat efficiency is approximately 80 % as ideal value. Accordingly, a heat quantity (approximately 17200 kcal/h: approximately 860 kcal/KWh × 20KW) is discharged from the fuel cell.

The following materials were chosen as the metal hydride that can efficiently utilize the heat. As the metal hydride having a high hydrogen equilibrium dissociation pressure, TiMn series such as TiMn1.5 · Hx, Ti0.9Zr0.1Mn1.6v0.2Cr0.2 · Hx series can be exemplified. On the other hand, as the metal hydride having a low hydrogen equilibrium dissociation pressure, Ti0.6Zr0.4Mn1.9Cu0.1 · Hx, VNb · Hx, CaNi5 · H series can be exemplified.

Now, supposing that an air heating and cooling (2000 kcal/h) is performed by utilizing the heat discharged from the fuel cell, the metal hydride TiMn1.5 · H2.4 can utilize 1.5W %

of hydrogen in theory. This is because a reaction heat H is approximately 7 kcal/molH2 for occluding hydrogen to /discharging hydrogen from the metal hydride $TiMn_{1.5} \cdot H_{2.4}$. Accordingly, the required heat quantity is 53 kcal/1kg to perform the air heating and cooling.

However, when hydrogen utilization efficiency and a heat loss due to a decrease of temperature are taken into a consideration, the heat that can be practically utilized is approximately 40kcal/kg. Herein, a heat quantity (2000 kcal/h) is required in order to perform an air heating and cooling. Thus the metal hydride (approximately 50 kg/h) is required in order to perform an air heating and cooling.

Based on this calculation, $TiMn \cdot Hx$ is utilized as the metal hydride having a high equilibrium dissociation pressure, while $C5Ni5 \cdot H2$ is utilized as the metal hydride having a low equilibrium dissociation pressure.

When the electric force (20KW) is output due to power generation of the fuel cell, a heat is discharged from the fuel cell. The metal hydroid having a high equilibrium dissociation pressure is heated by the heat. Thus hydrogen is discharged from the metal hydride so that an endothermic reaction occurs. At this time, an air heating and cooling (approximately 2000 Kcal/h) can be performed due to the heat caused by an endothermic reaction.

In the meantime, when the above system is used for supplying hot water, water having the temperature 15 to 20° C can be turned into hot water having the temperature of 40 to 60° C. Additionally, when a heat quantity of the metal hydirde is utilized to help the fuel cell with power generation, the temperature of the fuel cell can be increased so faster.

According to the embodiment described above, a pair of the metal hydrides (two kinds of the metal hydrides) as one system is connected with the fuel cell.

For example, supposing that more than two pairs of the metal hydrides as more than two systems can be connected with the fuel cell, an air heating and cooling can be performed by

means of one system, while the fuel cell can be heated by other systems. Accordingly, the air heating and cooling as well as a power generation of the fuel cell can be continuously performed by means of more than two systems. Specifically, the power generation of the fuel cell, the air heating and cooling, and a hot water supply can be continuously performed. Additionally, even when the fuel cell is not operated, the heat of the fuel cell can be stored in the metal hydride. Thus the stored heat can be efficiently utilized.

According to the embodiment of the present invention, when the electric force is output due to a power generation of the fuel cell, a heat is discharged from the fuel cell. The metal hydroid is heated by the heat. Thus hydrogen is discharged from the metal hydride so that an endothermic reaction occurs. At this time, an air heating and cooling can be efficiently performed due to the heat caused by an endothermic reaction. Accordingly, the system having the improved total heat efficiency can be provided. Furthermore, the heat discharged from the fuel cell can be stored in the metal hydrides, the stored heat can be utilized whenever it is required to use.

The EFFECT OF THE INVENTION

As described above, according to a fuel cell composite system of the present invention, the metal hydride having a low hydrogen equilibrium dissociation pressures is put in one metal tank, while the metal hydride having a high hydrogen equilibrium dissociation pressures is put in the other metal tank. These two metal tanks are coupled each other through the hydrogen transfer valves. Furthermore, the metal hydride having a low hydrogen equilibrium dissociation pressures is connected to the fuel cell via a heat exchanger. Thus an air heating and cooling and a hot water supply caused by the metal hydride is performed by utilizing a power generation of the fuel cell and a heat discharged from the fuel cell.

Accordingly, total heat efficiency of the system can be

improved. The air heating and cooling a well as a hot water supply can be continuously performed even the fuel cell is not operated. Furthermore, there are a few mobile parts in the system so that great noise is not generated when the fuel cell is driven. Additionally, since harmful gas is not emitted from the system when the fuel cell is driven, it is tender to an environment.

4. The BRIFE DESCRIPTION OF THE DRAWINGS

Fig.1 indicates a characteristic of a cooling and heating cycle with regard to two kinds of metal hydrides having different hydrogen equilibrium dissociation pressures.

Fig.2 indicates a constitution of composite system to perform a power generation of the fuel cell as well as an air heating and cooling caused by a metal hydride with regard to one embodiment of the present invention.

Fig.3 indicates a constitution of composite system to perform a power generation of the fuel cell as well as a hot water supply caused by a metal hydride with regard to one embodiment of the present invention.

1, 3, 6, 9, 16, 18: a heat exchanger
2, 7, 11, 12, 17, 20, 21: a valve
4, 10: a metal tank
5, 8: a joint pipe
13. 14: metal hydride
15: a fuel cell
19, 22, 23: a pipe for supplying water
24: a pipe for supplying hot water

冷暖房・給湯の複合システムの機能を有する点で実用的価値は大きい。

4、図面の簡単な説明

第1図は水素平衡圧力の異なる2種類の金属水素化物による冷却・加熱サイクルの特性を模式的に示す図、第2図は本発明の一実施例の燃料電池発電と金属水素化物による冷暖房を行なう複合システムの構成図、第3図は本発明の一実施例の燃料電池発電と金属水素化物による給湯を行なう複合システムの構成図である。

1，3，6，9，16，18……熱交換器、2，7，11，12，17，20，21……バルブ、4，10……金属容器、5，8……連結管、13，14……金属水素化物、15……燃料電池、19，22，23……給水用配管、24……給湯配管。

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Fig.1
~~第1図~~

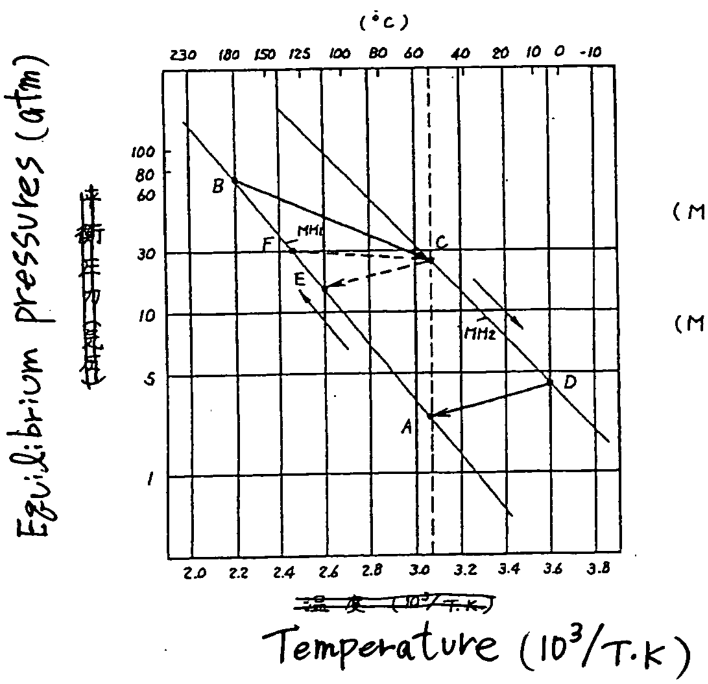


Fig.2
~~第2図~~

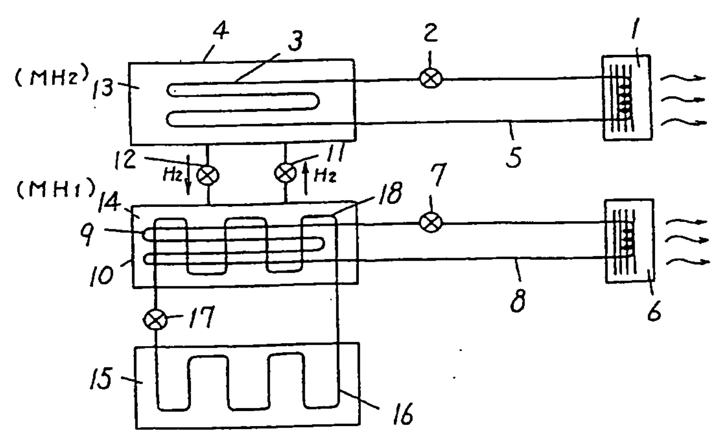
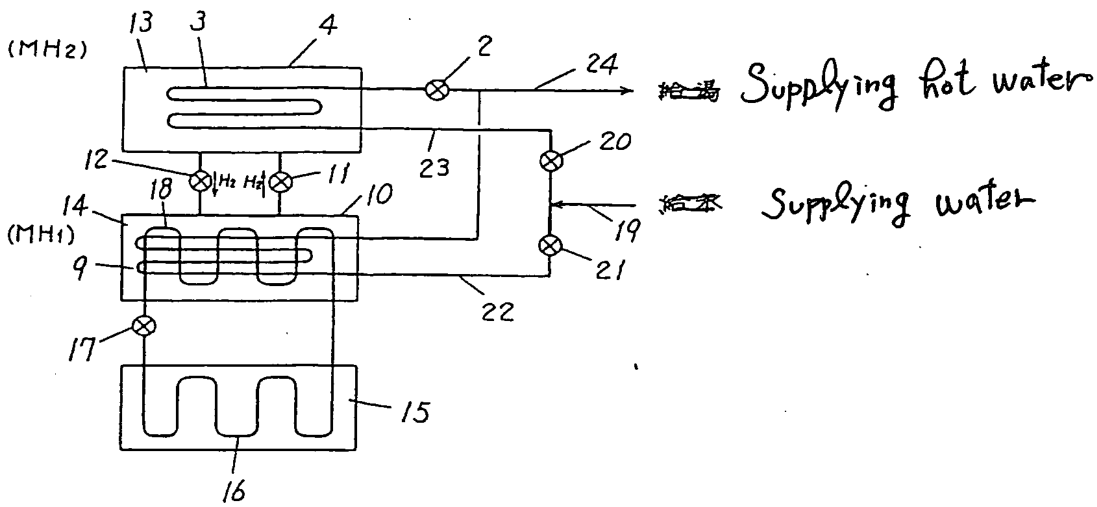


Fig.3

~~第3図~~


(MH2)
13
3
4
2
24
~~給湯~~ Supplying hot water
20
23
12
H_2
H_2
11
18
10
14
(MH1)
~~給水~~ Supplying water
19
9
21
22
17
15
16